

1. PUBLIC HEALTH STATEMENT

This public health statement tells you about cobalt and the effects of exposure.

The Environmental Protection Agency (EPA) identifies the most serious hazardous waste sites in the nation. These sites make up the National Priorities List (NPL) and are the sites targeted for long-term federal cleanup activities. Cobalt has been found in at least 404 of the 1,585 current or former NPL sites. ^{60}Co has been found in at least 11 of the 1,585 current or former NPL sites. However, the total number of NPL sites evaluated for cobalt is not known. As more sites are evaluated, the sites at which cobalt is found may increase. This information is important because exposure to this substance may harm you and because these sites may be sources of exposure.

When a substance is released from a large area, such as an industrial plant, or from a container, such as a drum or bottle, it enters the environment. This release does not always lead to exposure. You are exposed to a substance only when you come in contact with it. You may be exposed by breathing, eating, or drinking the substance, or by skin contact.

If you are exposed to cobalt, many factors determine whether you'll be harmed. These factors include the dose (how much), the duration (how long), and how you come in contact with it. You must also consider the other chemicals you're exposed to and your age, sex, diet, family traits, lifestyle, and state of health.

1.1 WHAT IS COBALT?

Cobalt is a naturally-occurring element that has properties similar to those of iron and nickel. It has an atomic number of 27. There is only one stable isotope of cobalt, which has an atomic weight of 59. (An element may have several different forms, called isotopes, with different weights depending on the number of neutrons that it contains. The isotopes of an element, therefore, have different atomic weights [number of protons and neutrons], although the atomic number [number of protons] remains the same.) However, there are many unstable or

1. PUBLIC HEALTH STATEMENT

radioactive isotopes, two of which are commercially important, cobalt-60 and cobalt-57, also written as Co-60 or ^{60}Co and Co-57 or ^{57}Co , and read as cobalt sixty and cobalt fifty-seven. All isotopes of cobalt behave the same chemically and will therefore have the same chemical behavior in the environment and the same chemical effects on your body. However, isotopes have different weights and the radioactive isotopes have different radioactive properties, such as their half-life and the nature of the radiation they give off. The half-life of a cobalt isotope is the time that it takes for half of that isotope to give off its radiation and change into a different isotope. Radioactive isotopes are constantly changing into different isotopes by giving off radiation, a process referred to as radioactive decay. The new isotope may be a different element or the same element with a different mass.

Small amounts of cobalt are naturally found in rocks, soil, water, plants, and animals. Cobalt is also found in meteorites. Elemental cobalt is a hard, silvery grey metal. However, cobalt is usually found in the environment combined with other elements such as oxygen, sulfur, and arsenic. Small amounts of these “chemical compounds” can be found in rocks, soil, plants, and animals. Cobalt is even found in water in dissolved or ionic form, typically in small amounts. (Ions are atoms, collections of atoms, or molecules containing a positive or negative electric charge.) A biochemically important cobalt compound is vitamin B₁₂ or cyanocobalamin. Vitamin B₁₂ is essential for good health in animals and humans. Cobalt is not currently mined in the United States. Therefore, we obtain cobalt and its other chemical forms from imported materials and by recycling scrap metal that contains cobalt.

Cobalt metal is usually mixed with other metals to form alloys. The cobalt makes the alloy hard or resistant to wear and corrosion. These alloys are used in a number of military and industrial applications such as aircraft engines, magnets, and grinding and cutting tools. They are also used in artificial hip and knee joints. Cobalt compounds are used as colorants in glass, ceramics, and paints, as catalysts, and as paint driers. Cobalt colorants have a characteristic blue color. Cobalt compounds are also used as trace element additives in agriculture and medicine.

^{60}Co is the most important radioisotope of cobalt. It is produced by bombarding natural cobalt, ^{59}Co , with neutrons in a nuclear reactor. ^{60}Co decays by giving off a beta ray (or electron) with a

1. PUBLIC HEALTH STATEMENT

half-life of 5.27 years, transforming into a stable isotope of nickel (atomic number 28). The decay is accompanied by the emission of high energy radiation called gamma rays. ^{60}Co is used as a source of gamma rays for sterilizing medical equipment and consumer products, radiation therapy for treating cancer patients, and for manufacturing plastics. ^{60}Co has also been used for food irradiation; depending on the radiation dose, this process may be used to sterilize food, destroy pathogens, extend the shelf-life of food, disinfest fruits and grain, delay ripening, and retard sprouting (e.g., potatoes and onions). ^{57}Co is used in medical and scientific research and has a half-life of 272 days. Another important cobalt isotope, ^{58}Co , is produced when nickel is exposed to a source of neutrons. Since nickel is used in nuclear reactors, ^{58}Co may be unintentionally produced and appear as a contaminant in cooling water released by nuclear reactors. ^{60}Co may be similarly produced from cobalt alloys in nuclear reactors and released as a contaminant in cooling water. ^{58}Co has a half-life of 71 days and gives off beta and gamma radiation in the process.

Quantities of radioactive cobalt can be measured in units of mass (grams), as is the stable isotope, but are normally measured in units of radioactivity (curies or becquerels). The becquerel (Bq) is a new international unit, and the curie (Ci) is a traditional unit; both are currently used. A becquerel is the amount of radioactive material in which 1 atom transforms every second, and a curie is the amount of radioactive material in which 37 billion atoms transform every second. For an overview of basic radiation physics, chemistry, and biology see Appendix D of this profile. For more information on radiation, see the *ATSDR Toxicological Profile for Ionizing Radiation*.

To learn more about the properties and uses of cobalt, see Chapters 5 and 6.

1.2 WHAT HAPPENS TO COBALT WHEN IT ENTERS THE ENVIRONMENT?

Cobalt occurs naturally in soil, rock, air, water, plants, and animals. It may enter air and water, and settle on land from wind-blown dust, seawater spray, volcanic eruptions and forest fires and may additionally get into surface water from runoff and leaching when rainwater washes through soil and rock containing cobalt. Small amounts of cobalt may be released into the atmosphere

1. PUBLIC HEALTH STATEMENT

from coal-fired power plants and incinerators, vehicular exhaust, industrial activities relating to the mining and processing of cobalt-containing ores, and the production and use of cobalt alloys and chemicals. ^{58}Co and ^{60}Co may be released to the environment as a result of nuclear accidents, radioactive waste dumping in the sea or in radioactive waste landfills, and nuclear power plant operations.

Cobalt cannot be destroyed in the environment. It can only change its form or become attached or separated from particles. Cobalt released from power plants and other combustion processes are usually attached to very small particles. Cobalt contained in wind-borne soil is generally found in larger particles than those released from power plants. These large particles settle to the ground or are washed out of the air by rain. Cobalt that is attached to very small particles may stay in the air for many days. Cobalt released into water may stick to particles in the water column or to the sediment at the bottom of the body of water into which it was released, or remain in the water column in ionic form. The specific fate of cobalt will depend on many factors such as the chemistry of the water and sediment at a site as well as the cobalt concentration and water flow. Cobalt deposited on soil is often strongly attached to soil particles and therefore would not travel very far into the ground. However, the form of the cobalt and the nature of the soil at a particular site will affect how far cobalt will penetrate into the soil. Both in soil and sediment, the amount of cobalt that is mobile will increase under more acidic conditions. Ultimately, most cobalt ends up in the soil or sediment.

When plants grow in highly contaminated soil, they accumulate very small amounts of cobalt, especially in the parts of the plant that you eat most often like the fruit, grain, and seeds. While animals that eat these plants will accumulate cobalt, cobalt is not known to biomagnify (produce increasingly higher concentrations) up the food chain. Therefore, vegetables, fruits, fish, and meat that you consume will generally not contain high amounts of cobalt. Cobalt is an essential element, required for good health in animals and humans, and therefore, it is important that foodstuffs contain adequate quantities of cobalt.

^{60}Co and ^{58}Co are moderately short-lived, man-made radioactive isotopes that are produced in nuclear reactors. Small amounts may be released to the environment as contaminants in cooling

1. PUBLIC HEALTH STATEMENT

water or in radioactive waste. However, these isotopes are not produced in nuclear weapons testing and are not associated with nuclear fallout. In the environment, radioactive isotopes of cobalt will behave chemically like stable cobalt. However, ^{60}Co and ^{58}Co will also undergo radioactive decay according to their respective half-lives, 5.27 years and 71 days.

For more information about what happens to cobalt in the environment, see Chapter 7.

1.3 HOW MIGHT I BE EXPOSED TO COBALT?

Cobalt is widely dispersed in the environment. You may be exposed to small amounts of cobalt by breathing air, drinking water, and eating food containing it. Children may also be exposed to cobalt by eating dirt. You may also be exposed by skin contact with soil, water, cobalt alloys, or other substances that contain cobalt. Analytical methods used by scientists to determine the levels of cobalt in the environment generally do not determine the specific chemical form of cobalt present. Therefore, we do not always know the chemical form of cobalt a person may be exposed to. Similarly, we do not know what forms of cobalt are present at hazardous waste sites. Some forms of cobalt may be insoluble or so tightly attached to particles or embedded in minerals that they are not taken up by plants and animals. Other forms of cobalt that are weakly attached to particles may accumulate in plants and animals.

The concentration of cobalt in soil varies widely, generally ranging from about 1 to 40 ppm (1 ppm = 1 part of cobalt in a million parts of soil by weight), with an average level of 7 ppm. Soils containing less than about 3 ppm of cobalt are considered cobalt-deficient because plants growing on them do not have sufficient cobalt to meet the dietary requirements of cattle and sheep. Such cobalt-deficient soils are found in some areas in the southeast and northeast parts of the United States. On the other hand, soils near cobalt-containing mineral deposits, mining and smelting facilities, or industries manufacturing or using cobalt alloys or chemicals may contain much higher levels of cobalt.

Usually, the air contains very small amounts of cobalt, less than 1–2 nanograms per cubic meter (ng/m^3). The amount of cobalt that you breathe in a day is much less than what you consume in

1. PUBLIC HEALTH STATEMENT

food and water. You may breathe in higher levels of cobalt in dust in areas near cobalt-related industries or near certain hazardous waste sites.

The concentration of cobalt in surface and groundwater in the United States is generally low—between 1 and 10 parts of cobalt in 1 billion parts of water (ppb) in populated areas; concentration may be hundreds or thousands times higher in areas that are rich in cobalt-containing minerals or in areas near mining or smelting operations. In most drinking water, cobalt levels are less than 1–2 ppb.

For most people, food is the largest source of cobalt intake. The average person consumes about 11 micrograms of cobalt a day in their diet. Included in this food is vitamin B₁₂, which is found in meat and dairy products. The recommended daily intake of vitamin B₁₂ is 6 micrograms (1 microgram = 1 millionth part of a gram).

You may also be exposed to higher levels of cobalt if you work in industries that make or use cutting or grinding tools, in metal mining, smelting, and refining, or in other industries that produce or use cobalt metal and cobalt compounds. Exposure will be reduced when exhaust systems are used in the workplace. Exposure will primarily result from breathing cobalt-containing dust.

When we speak of exposure to ⁶⁰Co, we are interested in exposure to the radiation given off by this isotope, primarily the gamma rays. The general population is rarely exposed to this radiation unless a person is undergoing radiation therapy. However, workers at nuclear facilities, irradiation facilities, or nuclear waste storage sites may be exposed to ⁶⁰Co or ⁵⁸Co. Exposures to radiation at these facilities are regulated and carefully monitored and controlled.

You can find more information on how you may be exposed to cobalt in Chapter 7.

1. PUBLIC HEALTH STATEMENT

1.4 HOW CAN COBALT ENTER AND LEAVE MY BODY?

Cobalt can enter your body when you breathe in air containing cobalt dust, when you drink water that contains cobalt, when you eat food that contains cobalt, or when your skin touches materials that contain cobalt. If you breathe in air that contains cobalt dust, the amount of inhaled cobalt that stays in your lungs depends on how big the dust particles are. The amount that is then absorbed into your blood depends on how well it will dissolve. If the particles dissolve easily, then it is easier for the cobalt to pass into your blood from the particles in your lungs. If the particles dissolve slowly, then they will remain in your lungs longer. Some of the particles will leave your lungs as they normally clean themselves out. Some of the particles will be swallowed into your stomach. The most likely way you will be exposed to excess cobalt is by eating contaminated food or drinking contaminated water. Levels of cobalt normally found in the environment, however, are not high enough to result in excess amounts of cobalt in food or water. The amount of cobalt that enters your body from food or water depends on many things including your state of health, the amount you eat or drink, and the number of days, weeks, or years you eat foods or drink fluids containing cobalt. If you do not have enough iron in your body, the body may absorb more cobalt from the foods you eat. Once cobalt enters your body, it goes into all tissues, mainly into the liver, kidney, and bones. After cobalt is breathed in or eaten, some of it leaves the body quickly in the feces. The rest is absorbed into the blood and then into the tissues throughout the body. The absorbed cobalt leaves the body slowly, mainly in the urine. Tests have shown that cobalt does not enter the body through normal skin, but it can if the skin has been cut.

Further information on how cobalt can enter or leave your body can be found in Chapter 3.

1.5 HOW CAN COBALT AFFECT MY HEALTH?

Cobalt has both beneficial and harmful effects on human health. Cobalt is beneficial for humans because it is part of vitamin B₁₂, which is essential to maintain human health. Cobalt (0.16–1.0 mg cobalt/kg of body weight) has also been used as a treatment for anemia (less than normal number of red blood cells), particularly in pregnant women, because it causes red blood

1. PUBLIC HEALTH STATEMENT

cells to be produced. Cobalt also increases red blood cell production in healthy people, but only at very high exposure levels. Cobalt is also essential for the health of various animals, such as cattle and sheep. Exposure of humans and animals to levels of cobalt normally found in the environment is not harmful.

When too much cobalt is taken into your body, however, harmful health effects can occur. People who breathed air containing 0.038 mg cobalt/m³ (about 100,000 times the concentration normally found in air) for 6 hours had trouble breathing. Serious effects on the lungs, including asthma, pneumonia, and wheezing have been found in people exposed to 0.003 mg cobalt/m³ at work. People exposed to 0.007 mg cobalt/m³ at work have also developed allergies to cobalt that resulted in asthma and skin rashes. The general public, however, is not likely to be exposed to the same type or amount of cobalt dust that caused these effects in workers.

In the 1960s, some breweries added cobalt to beer to stabilize the foam (0.04–0.14 mg cobalt/kg). Some people who drank excessive amounts of beer (8–25 pints/day) experienced serious effects on the heart. In some cases, these effects resulted in death. Vomiting and nausea usually occurred before the effects on the heart were noticed. Cobalt is no longer added to beer so you will not be exposed from this source. The effects on the heart, however, may have also been due to the fact that the beer-drinkers had protein-poor diets and may have already had heart damage from alcohol abuse. Effects on the heart were not seen, however, in people with anemia treated with up to 1 mg cobalt/kg, or in pregnant women with anemia treated with 0.6 mg cobalt/kg. Effects on the thyroid were found in people exposed to 0.5 mg cobalt/kg for a few weeks. Vision problems were found in one man following treatment with 1.3 mg cobalt/kg for 6 weeks, but this effect has not been seen in other human or animal studies.

Being exposed to radioactive cobalt can be very dangerous to your health. If you come near radioactive cobalt, cells in your body can become damaged from gamma rays that can penetrate your entire body, even if you do not touch the radioactive cobalt. Radiation from radioactive cobalt can also damage cells in your body if you eat, drink, breathe, or touch anything that contains radioactive cobalt. The amount of damage depends on the amount of radiation to which you are exposed, which is related to the amount of activity in the radioactive material and the

1. PUBLIC HEALTH STATEMENT

length of time that you are exposed. Most of the information regarding health effects from exposure to radiation comes from exposures for only short time periods. The risk of damage from exposure to very low levels of radiation for long time periods is not known. If you are exposed to enough radiation, you might experience a reduction in white blood cell number, which could lower your resistance to infections. Your skin might blister or burn, and you may lose hair from the exposed areas. This happens to cancer patients treated with large amounts of radiation to kill cancer. Cells in your reproductive system could become damaged and cause temporary sterility. Exposure to lower levels of radiation might cause nausea, and higher levels can cause vomiting, diarrhea, bleeding, coma, and even death. Exposure to radiation can also cause changes in the genetic materials within cells and may result in the development of some types of cancer.

To protect the public from the harmful effects of toxic chemicals and to find ways to treat people who have been harmed, scientists use many tests.

One way to see if a chemical will hurt people is to learn how the chemical is absorbed, used, and released by the body. In the case of a radioactive chemical, it is also important to gather information concerning the radiation dose and dose rate to the body. For some chemicals, animal testing may be necessary. Animal testing may also be used to identify health effects such as cancer or birth defects. Without laboratory animals, scientists would lose a basic method to get information needed to make wise decisions to protect public health. Scientists have the responsibility to treat research animals with care and compassion. Laws today protect the welfare of research animals, and scientists must comply with strict animal care guidelines.

Studies in animals suggest that exposure to high amounts of nonradioactive cobalt during pregnancy might affect the health of the developing fetus. Birth defects, however, have not been found in children born to mothers who were treated with cobalt for anemia during pregnancy. The doses of cobalt used in the animal studies were much higher than the amounts of cobalt to which humans would normally be exposed.

1. PUBLIC HEALTH STATEMENT

Non-radioactive cobalt has not been found to cause cancer in humans or in animals following exposure in the food or water. Cancer has been shown, however, in animals who breathed cobalt or when cobalt was placed directly into the muscle or under the skin. Based on the animal data, the International Agency for Research on Cancer (IARC) has determined that cobalt is possibly carcinogenic to humans.

Much of our knowledge of cobalt toxicity is based on animal studies. Cobalt is essential for the growth and development of certain animals, such as cows and sheep. Short-term exposure of rats to high levels of cobalt in the air results in death and lung damage. Longer-term exposure of rats, guinea pigs, hamsters, and pigs to lower levels of cobalt in the air results in lung damage and an increase in red blood cells. Short-term exposure of rats to high levels of cobalt in the food or drinking water results in effects on the blood, liver, kidneys, and heart. Longer-term exposure of rats, mice, and guinea pigs to lower levels of cobalt in the food or drinking water results in effects on the same tissues (heart, liver, kidneys, and blood) as well as the testes, and also causes effects on behavior. Sores were seen on the skin of guinea pigs following skin contact with cobalt for 18 days. Generally, cobalt compounds that dissolve easily in water are more harmful than those that are hard to dissolve in water. More information on how cobalt can affect your health can be found in Chapter 3.

Much of what we know about the effects of radioactive cobalt comes from studies in animals. The greatest danger of radiation seen in animals is the risk to the developing animal, with even moderate amounts of radiation causing changes in the fetus. High radiation doses in animals have also been shown to cause temporary or permanent sterility and changes in the lungs, which affected the animals' breathing. The blood of exposed animals has lower numbers of white blood cells, the cells that aid in resistance to infections, and red blood cells, which carry oxygen in the blood. Radioactive cobalt exposures in animals have also caused genetic damage to cells, cancer, and even death.

More information on how cobalt can affect your health can be found in Chapter 3.

1. PUBLIC HEALTH STATEMENT

1.6 HOW CAN COBALT AFFECT CHILDREN?

This section discusses potential health effects from exposures during the period from conception to maturity at 18 years of age in humans.

Children can be exposed to cobalt in the same ways as adults. In addition, cobalt may be transferred from the pregnant mother to the fetus or from the mother to the infant in the breast milk. Children may be affected by cobalt the same ways as adults. Studies in animals have suggested that children may absorb more cobalt from foods and liquids containing cobalt. Babies exposed to radiation while in their mother's womb are believed to be much more sensitive to the effects of radiation than adults.

1.7 HOW CAN FAMILIES REDUCE THE RISK OF EXPOSURE TO COBALT?

If your doctor finds that you have been exposed to significant amounts of cobalt, ask whether your children might also be exposed. Your doctor might need to ask your state health department to investigate.

Children living near waste sites containing cobalt are likely to be exposed to higher environmental levels of cobalt through breathing, touching soil, and eating contaminated soil. Some children eat a lot of dirt. You should discourage your children from eating dirt. Make sure they wash their hands frequently and before eating. Discourage your children from putting their hands in their mouths or hand-to-mouth activity.

Stable Cobalt. Since cobalt is naturally found in the environment, we cannot avoid being exposed to it. However, the relatively low concentrations present do not warrant any immediate steps to reduce exposure. If you are accidentally exposed to large amounts of cobalt, consult a physician immediately.

Radioactive Cobalt. You are unlikely to be exposed to high levels of radioactive cobalt unless you are exposed as part of a radiotherapy treatment, there is an accident involving a cobalt

1. PUBLIC HEALTH STATEMENT

sterilization or radiotherapy unit, or there is an accidental release from a nuclear power plant. In such cases, follow the advice of public health officials who will publish guidelines for reducing exposure to radioactive material when necessary. Workers who work near or with radioactive cobalt should follow the workplace safety guidelines of their institution carefully to reduce the risk of accidental irradiation.

1.8 IS THERE A MEDICAL TEST TO DETERMINE WHETHER I HAVE BEEN EXPOSED TO COBALT?

We have reliable tests that can measure cobalt in the urine and the blood for periods up to a few days after exposure. The amount of cobalt in your blood or urine can be used to estimate how much cobalt you were exposed to. The tests are not able to accurately predict potential health effects following exposure to cobalt.

It is difficult to determine if a person has been exposed only to external radiation from radioactive cobalt unless the radiation dose was rather large. Health professionals examining people who have health problems similar to those resulting from radiation exposure would need to rely on additional information in order to establish if such people had been near a source of radioactivity. More information on medical tests can be found in Chapters 3 and 7.

1.9 WHAT RECOMMENDATIONS HAS THE FEDERAL GOVERNMENT MADE TO PROTECT HUMAN HEALTH?

The federal government develops regulations and recommendations to protect public health. Regulations can be enforced by law. Federal agencies that develop regulations for toxic substances include the Environmental Protection Agency (EPA), the Occupational Safety and Health Administration (OSHA), the Food and Drug Administration (FDA), and the Nuclear Regulatory Commission (NRC).

Recommendations provide valuable guidelines to protect public health but cannot be enforced by law. Federal organizations that develop recommendations for toxic substances include the

1. PUBLIC HEALTH STATEMENT

Agency for Toxic Substances and Disease Registry (ATSDR) and the National Institute for Occupational Safety and Health (NIOSH), and the FDA.

Regulations and recommendations can be expressed in not-to-exceed levels in air, water, soil, or food that are usually based on levels that affect animals; then they are adjusted to help protect people. Sometimes these not-to-exceed levels differ among federal organizations because of different exposure times (an 8-hour workday or a 24-hour day), the use of different animal studies, or other factors.

Recommendations and regulations are also periodically updated as more information becomes available. For the most current information, check with the federal agency or organization that provides it. Some regulations and recommendations for cobalt include the following:

EPA requires that the federal government be notified if more than 1,000 pounds of cobalt (as the bromide, formate, and sulfamate compounds) are released into the environment in a 24-hour period. OSHA regulates levels of nonradioactive cobalt in workplace air. The limit for an 8-hour workday, 40-hour workweek is an average of 0.1 mg/m³.

1.10 WHERE CAN I GET MORE INFORMATION?

If you have any more questions or concerns, please contact your community or state health or environmental quality department, your regional Nuclear Regulatory Commission office, or:

Agency for Toxic Substances and Disease Registry
Division of Toxicology
1600 Clifton Road NE, Mailstop E-29
Atlanta, GA 30333

* Information line and technical assistance

Phone: 1-888-42-ATSDR (1-888-422-8737)
Fax: (404) 498-0057

1. PUBLIC HEALTH STATEMENT

ATSDR can also tell you the location of occupational and environmental health clinics. These clinics specialize in recognizing, evaluating, and treating illnesses resulting from exposure to hazardous substances.

* To order toxicological profiles, contact

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Phone: 1-800 -553-6847 or (703) 605-6000